NGI: A Glimpse Into the Future

Internet2 and Indiana University
April 9, 1998

Kay Howell, Director
National Coordination Office
for Computing, Information, and Communications

Famous Quotes about the Future of Computing

- "I think there is a world market for maybe five computers." **Thomas Watson, chairman of IBM, 1943.**
- "Computers in the future may weigh no more than 1.5 tons." **Popular Mechanics, forecasting the relentless march of science, 1949**
- "I have traveled the length and breadth of this country and walked with the best people, and I can assure you that data processing is a fad that won't last out the year." **Editor in charge of business books for Prentice Hall, 1957**
- "But what ... is it good for?" **Engineer at the Advanced Computing Systems Division of IBM, commenting on the microchip, 1968**
- "There is no reason anyone would want a computer in their home." **Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977**
- "So we went to Atari and said, 'Hey, we've got this amazing thing, even built with some of your parts, and what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary, we'll come work for you' And they said, 'No.' So then we went to Hewlett-Packard, and they said, 'Hey we don't need you. You haven't got through college yet.'" **Apple Computer Inc. founder Steve Jobs on attempts to get Atari and HP interested in his and Steve Wozniak's personal computer**
- "640K ought to be enough for anybody." **Bill Gates, 1981**

Next Generation Internet (NGI)

Imagine an Internet a thousand times faster than today:

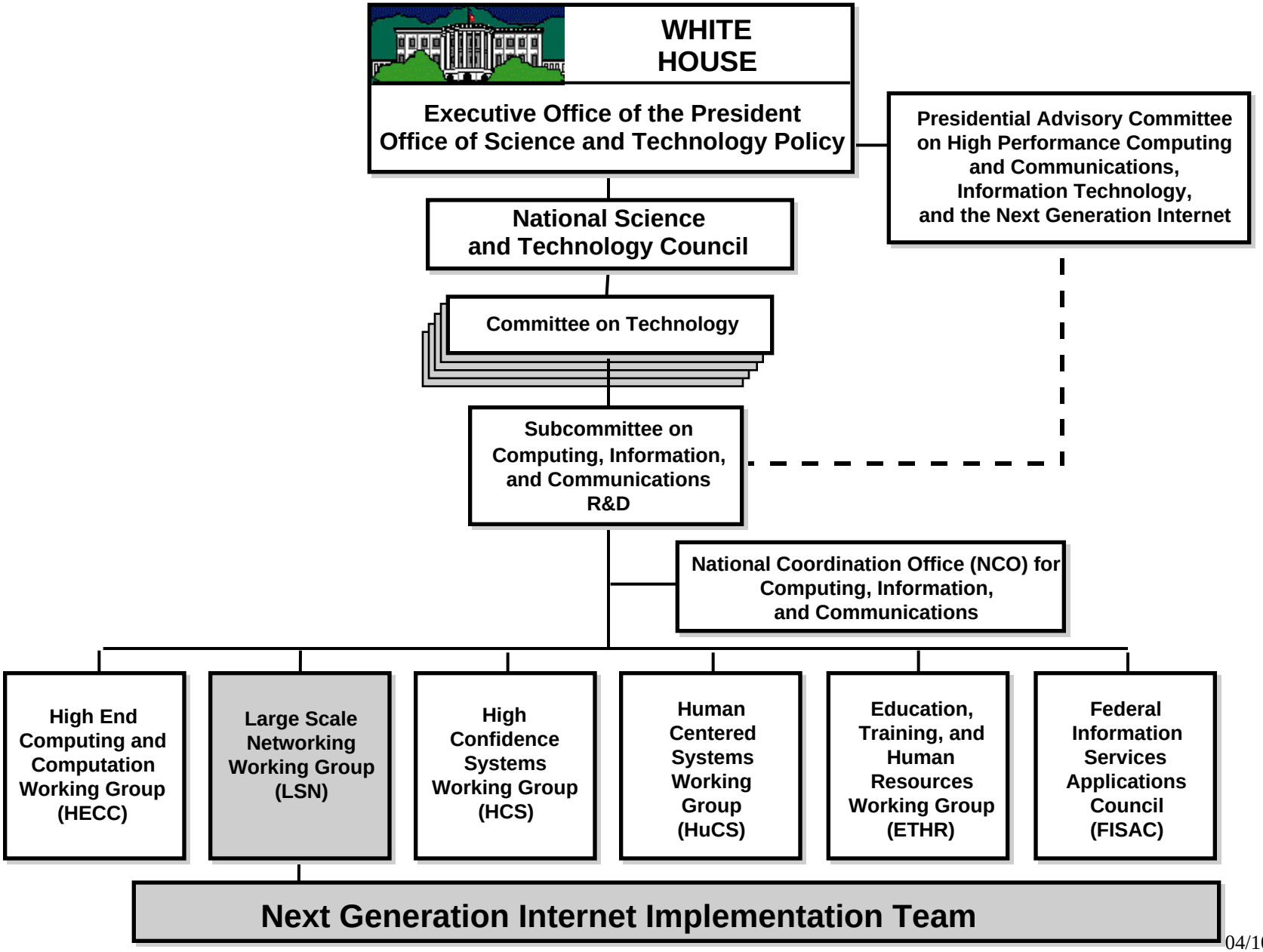
- An Internet so ubiquitous that it interconnects all Americans regardless of location, age, income, or health
- An Internet so safe and reliable that Americans confidently use it of their most important communications
- An Internet so intelligent that it can be used effortlessly to help us preserve our environment, improve our productivity, and get first rate medical care

NGI Initiative

The Next Generation Internet initiative is a multi-agency Federal R&D program that will:

- Develop new and more capable networking technologies to support Federal agency missions
- Create a foundation for more powerful and versatile networks in the 21st century
- Form partnerships with academia and industry that will keep the U.S. at the cutting edge of information and communications technologies
- Enable the introduction of new networking services that will benefit our businesses, schools, and homes

How the NGI Initiative is Coordinated



Large Scale Networking

- Goal is U.S. technological leadership
- Research in networking technologies, services, and performance:
  - Wireless, optical, mobile, wireline
  - Disseminating information to individuals, groups (multicast), or entire networks (broadcast)
  - Developing and executing scalable distributed applications
  - Engineering and managing large scale networks
- Testbeds and research infrastructure
- Includes Next Generation Internet (NGI) initiative

FY 1998 Participating Agencies

- DARPA: Defense Advanced Research Projects Agency
- NASA: National Aeronautics and Space Administration
- NIH: National Institutes of Health
- NIST: National Institute of Standards and Technology
- NSF: National Science Foundation

NGI Budgets

Agency	FY 1998	Proposed FY 1999
DARPA	$42	$40
NSF	23	25
DoE		25
NASA	10	10
NIST	5	5
NIH/NLM	5	5
Total	$85	$ 110

NGI Implementation Plan

Next Generation Internet

Implementation Plan

February 1998

Second Printing

Large Scale Networking
Next Generation Internet Implementation Team

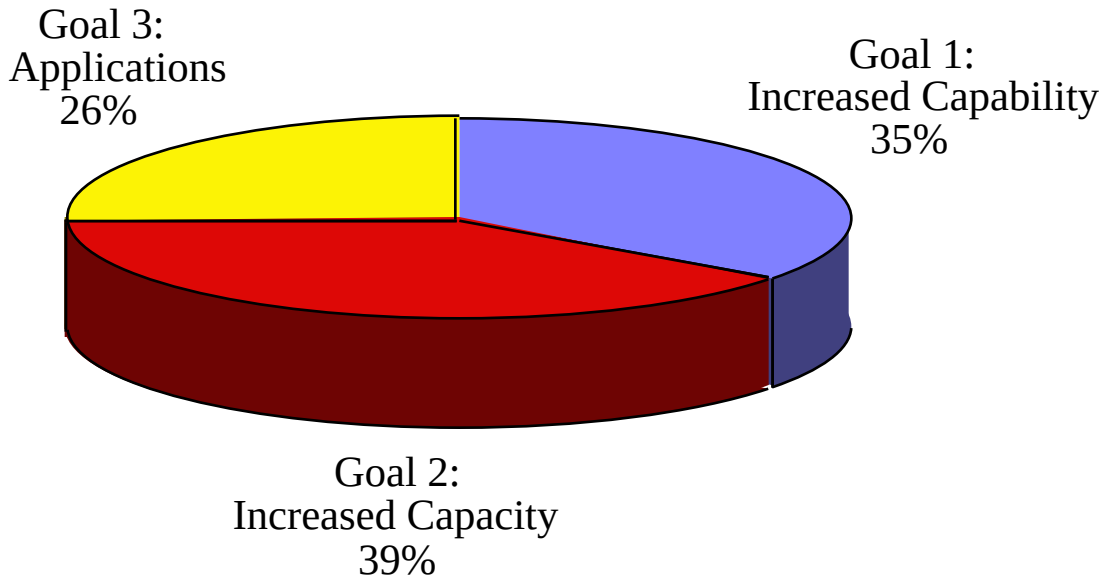
Note: This plan incorporates the comments received from the Presidential Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet; Members of Congress and their staff; an NGI workshop sponsored by Computer Research Association, Computer Systems Policy Project, and Cross Industry Working Team; industry; academia; and the public.

Comments are always encouraged. Please send them to ngi@ccic.gov or fax them to 703-306-4727. If you need additional information, please contact the National Coordination Office for Computing, Information, and Communications at 703-306-4722.

Goals and Metrics

Initiative Goals	Metrics
1. Promote experimentation with the next generation of network technologies	• Quality of service including security • Adoption of technologies by private sector
2. Develop a next generation network testbed to connect universities and federal research institutions at rates that are sufficient to demonstrate new technologies and support future research	• Ability of network testbed to accommodate goal 1 research results and goal 3 applications • 100-1000 times end-to-end performance improvement • About 100 research institutions connected
3. Demonstrate new applications that meet important national goals and missions	• 100+ high-importance applications • Value of applications in testing networking technologies

NGI FY 1998 Funding by Goal



Goal 1: Increased Capability

Conduct R&D in advanced end-to-end networking technologies:

- Reliability
- Robustness
- Security
- Quality of service/differentiation of service (including multicast and video)
- Network management (Including allocation and sharing of bandwidth)

Goal 2: Increased Capacity

Establish and operate two testbeds

- The “100x” testbed will connect at least 100 sites — universities, Federal research institutions, and other research partners — at speeds 100 times faster end-to-end than today’s Internet.
- The testbed will be built on the following Federal networks:
  - NSF’s very high performance Backbone Network Service (vBNS)
  - NASA’s Research and Education Network (NREN)
  - DoD’s Defense Research and Education Network (DREN)
  - DoE’s Energy Sciences network (ESnet) (proposed beginning in FY 1999)

Network Classifications

- Class 1: Networking Research
  "Bleeding edge, breakable networks"
- Class 2: Research Networks
  "Leading edge, advanced application enabled"
- Class 3: Operational Networks
  "State-of-the-art technology"
- Class 4: Production Networks
  "Commercially available technology"

NGI Focus: Class 1 and 2 networks

Goal 2: Increased Capacity (cont'd)

- The "1,000x" testbed will connect about 10 sites with end-to-end performance at least 1,000 times faster than today's Internet. The Federal networks on which this testbed will be built include:
  - Multi-agency Washington, DC area Advanced Technology Demonstration network (ATDnet)
  - DARPA's ACTS ATM Internetwork (AAI)
    (ACTS is NASA's Advanced Communication Technology Satellite)
- These testbeds will be used for system-scale testing of advanced technologies and services and for development and testing advanced applications

Goal 3: Applications

- Conduct R&D in revolutionary applications
- These include enabling applications technologies:
  - Collaboration technologies
  - Digital libraries
  - Distributed computing
  - Privacy and security
  - Remote operation and simulation

Goal 3: Applications (cont'd)

- And disciplinary applications:
  - Basic science
  - Crisis management
  - Education
  - The environment
  - Federal Information services
  - Health care
  - Manufacturing

Netamorphosis

- March 11-13, 1998
- Highway 1 in Washington, D.C.
- A demonstration of advanced networking technologies and promising new medical, environmental, and manufacturing applications enhanced by Federal R&D programs like the NGI initiative
- Eighteen demonstrations including.....


A collaboratory for structure-based
Drug Design
A prototype collaborative environment for carrying out interactive 3-dimensional studies of molecular structure among scientists at distant locations.
SPONSORS
• NIH: National Center for Research Resources
PERFORMERS
• Collagen Corporation
• State University of New York at Stony Brook
• University of California Computer Graphics Laboratory
• University of Washington
USERS & USES
The collaboratory is used for drug design, protein engineering, biomaterials design and fabrication, and bioremediation.
NGI RESEARCH NEEDS
Advancements in high performance network access, collaborative molecular modeling software and desktop videoconferencing.
Primary Contact: Thomas Ferrin, University of California, San Francisco
Web Site: http://www.cgl.ucsf.edu/home/research/collaboratory/

Interactive Echocardiography over the Next Generation Internet

Interactive Echocardiography (EC) generates full-motion video of cardiac structure and cardiovascular blood flow and delivers these images in real-time to physicians in remote locations.

SPONSOR

- NASA

PERFORMERS

- Cleveland Clinic Foundation Imaging Center
- NASA:
  - Ames Research Center
  - Johnson Space Center
  - Lewis Research Center

PARTNER

- NUKO Information Systems, Inc.

USERS & USES

Cleveland Clinic Foundation and satellite facilities in Ohio and Florida, and the Clinic's outpatient labs currently use interactive echocardiography. Echocardiographs are transmitted from the cardiac operating room to remote locations so that cardiologists can provide guidance even when they are not physically present. Echocardiography images are also relayed from satellite facilities to the main facility for diagnosis. Remote echocardiography will be critical for the future International Space Station, in battlefield conditions, and in medically underserved areas around the world.

NGI RESEARCH NEEDS

Increased bandwidth and end-to-end Quality of Service guarantees to distribute 30 megabytes/second of full-screen, full-motion image data over wide-area networks.

Primary Contact: Dr. James Thomas, Cleveland Clinic Foundation

Web Site: *http://www.nren.nasa.gov/echo.html*


Real-time
Functional MRI
Watching the brain in action
The Brain in Action allows remote viewing of brain activity while a patient is performing cognitive or sensory-motor tasks.
SPONSORS
NIH
National Center for Research Resources
National Institute of Mental Health
National Institute on Drug Abuse
NSF
PERFORMERS
Carnegie Mellon University
Pittsburgh Supercomputing Center
University of Pittsburgh
University of Pittsburgh Medical Center
USERS & USES
Neurosurgeons, neurologists, psychiatrists, and brain scientists will investigate brain function and diagnose and treat brain diseases. For example, this application will enable neurosurgeons to develop surgical plans for tumor removal based on an understanding of the cognitive and sensory-motor abilities located near a tumor site.
NGI RESEARCH NEEDS
Improvements in available capacity, interactive real-time capability, security, privacy, and integration with advanced computing to ensure high performance, wide-spread availability, online visualization, and patient confidentiality.
Primary Contact: Nigel Goddard, Pittsburgh Supercomputing Center
Web Site: http://www.psc.edu/science/goddard.html

Nanotechnology Research

Controlling atoms from a distance

The Scanning Tunneling Microscope (STM) can measure and manipulate atomic structures (measured in nanometers, or billionths of a meter), whose images have been magnified to a workable human scale. The Field Ion Microscope (FIM) is used to shape the STM's probe, or tip, so it can accurately measure these structures.

SPONSOR

- NIST

PERFORMERS & PARTNERS

- EMCOR
- Kurt J. Lesker Co.
- Sandia National Laboratories
- NIST
- Topometrix
- University of Maryland

USERS & USES

Manufacturing researchers use the STM and its close relative, the Atomic Force Microscope, as quality control tools for developing standard measurements of small-scale products and their component parts, such as computer chips and their circuitry.

NGI RESEARCH NEEDS

A high-speed, secure, reliable network and simultaneous voice, video, and data transmission to make these microscopes, located at NIST's Gaithersburg, MD campus, accessible by "remote control" to companies and universities nationwide.

Primary Contact: Theodore Vorburger, NIST/MEL

Web Site: *http://www.nist.gov/mel/namt/*

Octahedral Hexapod

An Information Age machine tool

The hexapod is an innovative experimental metal-cutting machine tool with the potential to deliver an unprecedented combination of versatility, speed, accuracy, and portability.

SPONSOR

- NIST

PERFORMERS & PARTNERS

- Deneb Robotics
- Ingersoll Milling Machine Co.
- NIST
- Ohio State University
- Sandia National Laboratories
- United Technologies Research Center/Pratt & Whitney
- University of Florida
- University of Maryland

Additional Hexapod User Group Partners

- Allied Signal Corp.
- Eaton Corporation
- Giddings and Lewis
- Hexel Corporation
- Massachusetts Institute of Technology
- NASA Johnson Space Flight Center
- Oak Ridge National Laboratory

USERS & USES

Industry and university researchers are working with NIST to investigate the hexapod's potential performance advantages — from lower production costs to faster methods for making parts, molds, and dies.

NGI RESEARCH NEEDS

Real-time, full-motion video plus 15 Mbps bandwidth in a dedicated, secure environment — technology not widely available and currently prohibitively expensive for most organizations that can contribute to and benefit from network-enabled manufacturing research collaborations.

Primary Contact: Albert Wavering, NIST/MEL

Web Site: *http://www.nist.gov/mel/namt/*

Automating the construction site

A leap in capabilities

TETRA, a versatile robotic crane, is one of several experimental technologies being investigated at NIST's new National Construction Automation Testbed. These technologies will be used in developing standards for wireless tracking, positioning, and control of machines at construction sites and for supporting interactive, construction management systems.

SPONSOR

- NIST

PERFORMERS & PARTNERS

- Arc-Seconds, Inc.
- Carnegie Mellon University
- Integrinautics, Inc.
- Jacobus Technologies, Inc.
- NIST
- North Carolina State University
- Trimble Navigation Ltd.
- University of Maryland

USERS & USES

At NCAT, researchers are developing an infrastructure for modeling, simulation, and automation of dangerous or error-prone construction tasks; remote site-management; and up-to-the-moment access to all site-related information — from architectural designs to subcontractor schedules to the status of machinery. Anticipated benefits include improvements in safety, productivity, and quality.

NGI RESEARCH NEEDS

The transmission and processing of huge volumes of position data and other information originating from global positioning satellites, hard-hat-mounted displays, and innovative surveying systems for wireless tracking of machines and other construction-site components.

Primary Contact: William Stone, NIST/BFRL

Web Site: *http://www.nist.gov/mel/namt/*

Sources of Applications

- Single agency mission
- NGI affinity groups
  - Coordinate NGI applications
  - Identify discipline and technology areas
  - Coordinate applications development for its area of interest
  - Harmonize requirements needed by its applications
- Federal Information Services Applications Council
  - Other Federal applications
- Broad solicitations

Functions of Applications Process

- Identify applications requiring NGI bandwidth or services
- Encourage agencies to think “out of the box”
- Identify needs common to other affinity groups
- Coordinate and transfer common elements among applications
- Transmit NGI capability requirements to implementation teams for goals 1 and 2
- Harmonize the implementation schedules of the applications and goals 1 and 2

NGI and Internet2: Complementary and Interdependent

Next Generation Internet

- Federal funding
- Agency mission driven
- R&D in advanced networking technologies and demonstrations on a wide-area scalable testbed, which connects to academic (including some Internet2 universities) and industry networks
- Develop general-purpose and agency-specific applications

Internet2

- Funded by research universities and communications and computing companies
- Education and research driven
- State-of-the-practice connectivity deployed at universities and GigaPOPs (Gigabit per second points of presence), and interconnected using NSF's vBNS as the backbone
- Deploy networking technologies and develop a wide range of applications (many funded by Federal initiatives such as the NGI)

NGI and Internet2

- Ways the Federal NGI initiative and the university-led Internet2 work together include:
  - Seventy seven of the 92 institutions approved by NSF for high performance connections to its vBNS are Internet2 universities. vBNS connectivity is a key part of NSF's NGI program
  - NGI and Internet2 will help ensure that advanced networking services are available on interoperable backbone, regional, and local networks that are competitively provided by multiple vendors
  - Many of the applications developed by researchers at Internet2 universities that require advanced networking are funded by Federal initiatives including the NGI

Presidential Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet

- Established February 1997 by Executive Order 13035
- Membership consists of 25 non-federal members; community representatives from research, education, and libraries; network providers; and critical industries
- Provides the National Science and Technology Council, through the Director, OSTP, with advice and information on high-performance computing and communications, information technology, and the Next Generation Internet
- Chaired by Ken Kennedy, Rice University and Bill Joy, Sun Microsystems

Advisory Committee Functions

- Independent assessment of:
  - Progress made in implementing the High Performance Computing and Communications (HPCC) Program
  - Progress in designing and implementing the Next Generation Internet initiative
  - The need to revise the HPCC Program
  - Balance among components of the HPCC Program
  - Whether the research and development undertaken pursuant to the HPCC Program is helping to maintain United States leadership in advanced computing and communications technologies and their applications
  - Other issues as specified by the Director
- Interim report due June 1998; final report due January 1999

Questions?

Subcommittee on CIC R&D

- Provides coordination, planning, budgeting, and review of multi-agency CIC R&D programs
- Oversees activities of five Program Component Area (PCA) Working Groups and the Federal Information Services and Applications Council (FISAC)
- Coordinates planning activities with OSTP and budget activities with OMB
- Provides technical assistance to and coordinates implementation of recommendations of the Presidential Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet
- Membership consists of representatives from twelve agencies/ departments, OSTP, and OMB
- Chaired by the NCO Director

NCO Responsibilities (1)

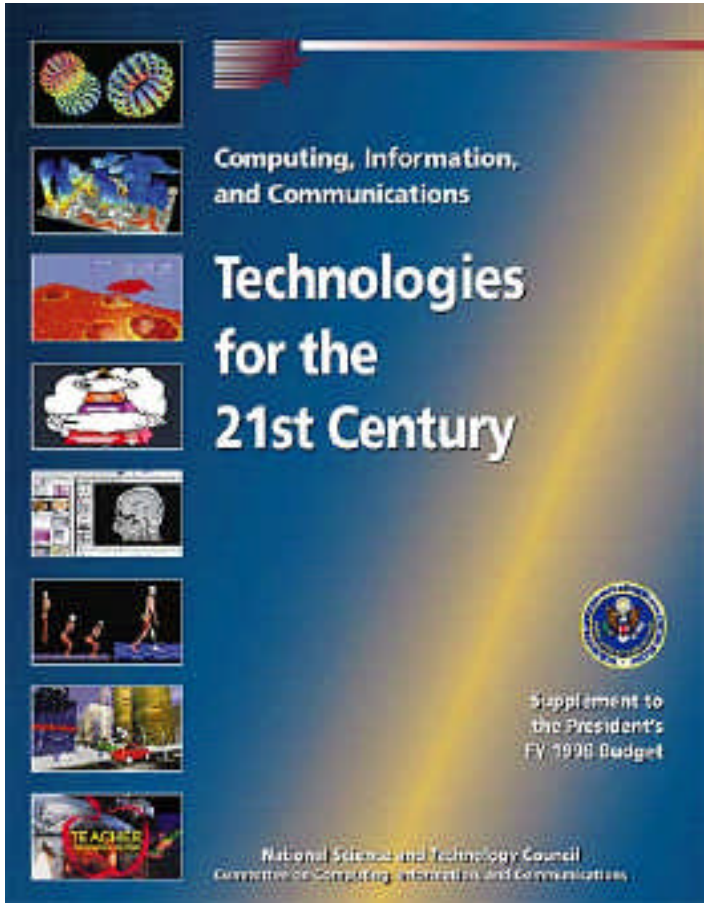
- Work with OSTP and OMB to help the President set the Federal computing, information, and communications R&D agenda and budgets
- Justify the agenda and budgets to Congress
  - Testimony
  - Staff briefings

NCO Responsibilities (2)

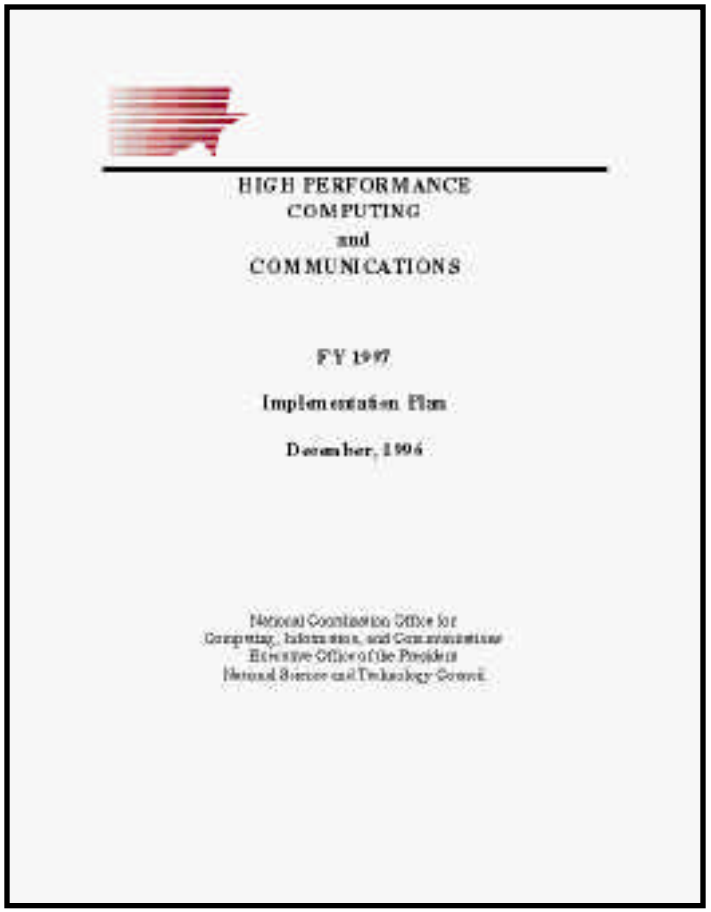
- Document the coordinated Federal CIC R&D programs
  - Accomplishments
  - Plans
  - Budgets
  - Who does this work
- Outreach to other Federal agencies, state and local organizations, foreign organizations, academia, industry, and the public

NCO Publications

FY 1998 Brochure



FY 1998 Blue Book


HIGH PERFORMANCE COMPUTING and COMMUNICATIONS

FY 1997

Implementation Plan

December, 1996

FY 1997 Implementation Plan

Participating Agencies and Departments

Defense Advanced Research Projects Agency (DARPA)
National Science Foundation (NSF)
Department of Energy (DoE)
National Aeronautics and Space Administration (NASA)
National Institutes of Health (NIH)
National Security Agency (NSA)
National Institute of Standards and Technology (NIST)
Department of Veterans Affairs (VA)
Department of Education (ED)
National Oceanic and Atmospheric Administration (NOAA)
Environmental Protection Agency (EPA)
Agency for Health Care Policy and Research (AHCPR)

CIC R&D Structure

- Five Program Component Areas (PCAs)
  - High End Computing and Computation (HECC)
  - Large Scale Networking (LSN)
  - High Confidence Systems (HCS)
  - Human Centered Systems (HuCS)
  - Education, Training, and Human Resources (ETHR)
- Each PCA
  - Spans areas of multiple agencies involvement
  - Includes hardware, software, algorithms, and applications
  - Focuses on specific R&D goals, ensures adequate investments, and maintains necessary budget visibility
  - Technology R&D may span PCAs
  - Applications span PCAs
  - Formal budget crosscuts reported for two PCAs